LUNAR MAPPING AND CONSTRUCTION IN SUPPORT OF SPACE PROGRAMS

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LUNAR MAPPING AND CONSTRUCTION IN SUPPORT OF SPACE PROGRAMS

TUESDAY, MAY 10, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met, pursuant to notice, at 10:03 a.m., in Room 214–B, New House Office Building, Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee will come to order.

This morning we are privileged to have Gen. Emerson C. Itschner, Chief of Engineers, Department of the Army. He is accompanied by Dr. Gilford G. Quarles, chief scientist, Corps of Engineers; Lt. Col. George E. Hesselbacher, military construction officer; Col. John D. Cole, Chief, Plans and Policies; Lt. Col. Earle G. Peacock, plans and policy officer; and Mr. Harry N. Lowe, Jr., engineer, R. & D. Laboratory, from Fort Belvoir, Va.

This morning we begin new hearings that I think the committee will be interested in as we go along.

General Itschner has a prepared statement, and I will ask the general if he will proceed with his statement.

STATEMENT OF LT. GEN. EMERSON C. ITSCHNER, CHIEF OF ENGINEERS, U.S. ARMY; ACCOMPANIED BY DR. GILFORD G. QUARLES, CHIEF SCIENTIST, CORPS OF ENGINEERS; LT. COL. GEORGE E. HESSELBACHER, MILITARY CONSTRUCTION OFFICER, OFFICE OF CHIEF OF ENGINEERS; COL. JOHN D. COLE, CHIEF, PLANS AND POLICIES, OFFICE OF CHIEF OF ENGINEERS; LT. COL. EARLE G. PEACOCK, PLANS AND POLICY OFFICER, OFFICE OF CHIEF OF ENGINEERS; AND HARRY N. LOWE, JR., ENGINEER, R. & D. LABORATORY, FORT BELVOIR

General ITSCHNER. Mr. Chairman and gentlemen; it is an unsual honor to meet with your committee in its investigation of the highly important subjects of science and astronautics.

In view of your interest in the Army's capabilities and role in space, I welcome this opportunity to discuss with you some important contributions and capabilities of the Corps of Engineers in support of our national space program. I have selected four areas to which my remarks will be addressed. They are (1) mapping and geodesy of the Earth, (2) mapping the Moon, (3) terrestrial construction in support of space activities, (4) construction on the Moon in support

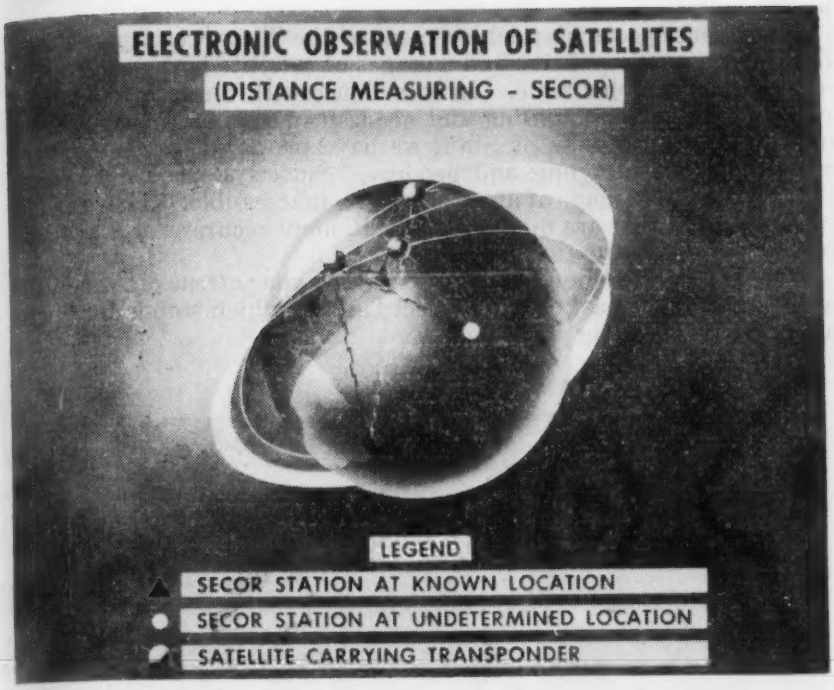
of the men who must live and work there. This area is one not always fully appreciated.

Secretary Brucker and General Lemnitzer have outlined to you the Army's interest and role in space; they stressed the Army's capabilities, competence, and desire to provide maximum support for our national space effort—in both military and nonmilitary fields. Your committee is familiar with examples of nonmilitary support the Corps of Engineers has rendered the Nation in such endeavors as flood control and navigation works, construction of the Panama Canal and the U.S. portion of the St. Lawrence Seaway, and the exploration and surveying of the American West. Such endeavors as these provide both the background and the precedent for our supporting, not just DOD space systems, but rather the entire national space effort.

During the International Geophysical Year, the corps built and operated the Vanguard Minitrack north-south fence in South America. Since 1958 the Corps of Engineers has been observing under Project Betty the Vanguard satellite and more recently the Tiros and Transit satellites in order to obtain geodetic data, such as the size and shape of the Earth, intercontinental ties, and the location of remote Pacific islands. We will soon have a new radio device aboard one of the Navy's Transit satellites which, with its associated ground stations, will considerably improve our ability to observe satellites for geodetic purposes.

This new device is called Secor (fig. 1) which stands for "sequential correlation of range." It is an electronic distance-measuring system which will enable us to make intercontinental ties. Considering only the satellite pass shown in pink and the range measurements to the satellite shown in yellow, we can locate a point in Europe with respect to three stations at known locations in North America and South America.

FIGURE 1



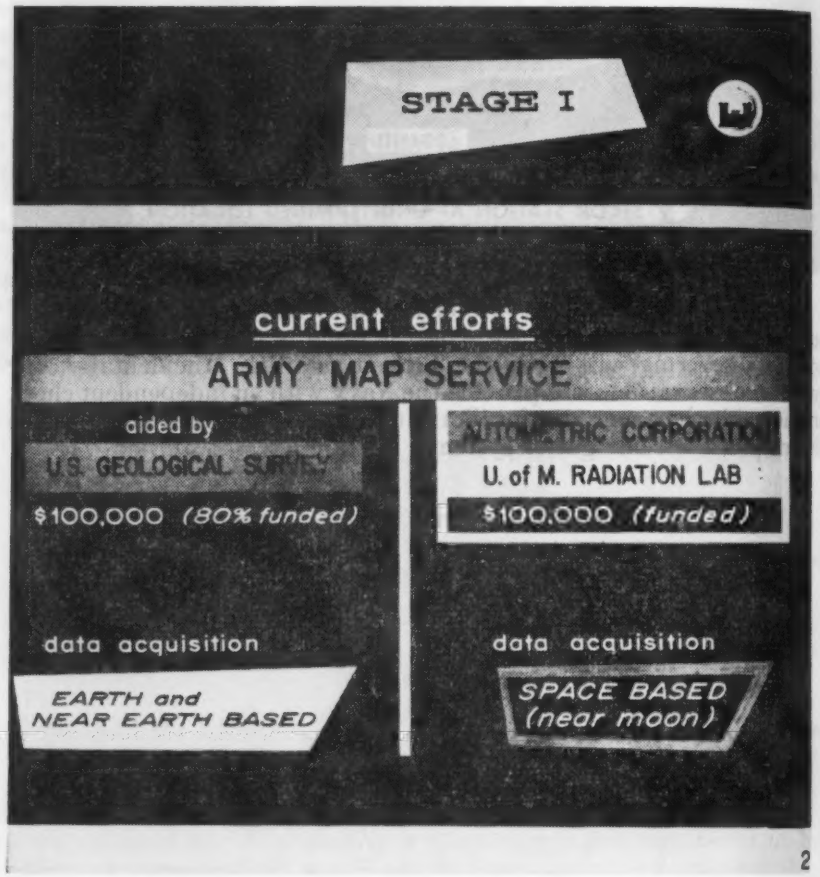
Subsequent orbital passes are observed to increase the accuracy of our range measurements. Here on the table is a model of the transponder the Army will fly in the Transit satellite. Incidentally, our geodetic observations will provide the Navy with an independent check on the orbit they compute for Transit, and thus will contribute to the accuracy of their navigation system.

Expansion of these stations to include optical tracking equipment is being planned.

The recent spectacular achievement of the Tiros weather-eye satellite illustrates the potential advantages of satellite-borne cameras for mapping on a global scale. In accordance with the Army's assigned responsibilities for mapping and geodesy in support of all agencies under the Joint Chiefs of Staff, we have proposed satellite systems specifically for mapping and geodesy. Such systems would enable the production of maps of areas otherwise inaccessible. They can also produce maps that are more economical, more accurate, and available sooner than by conventional means.

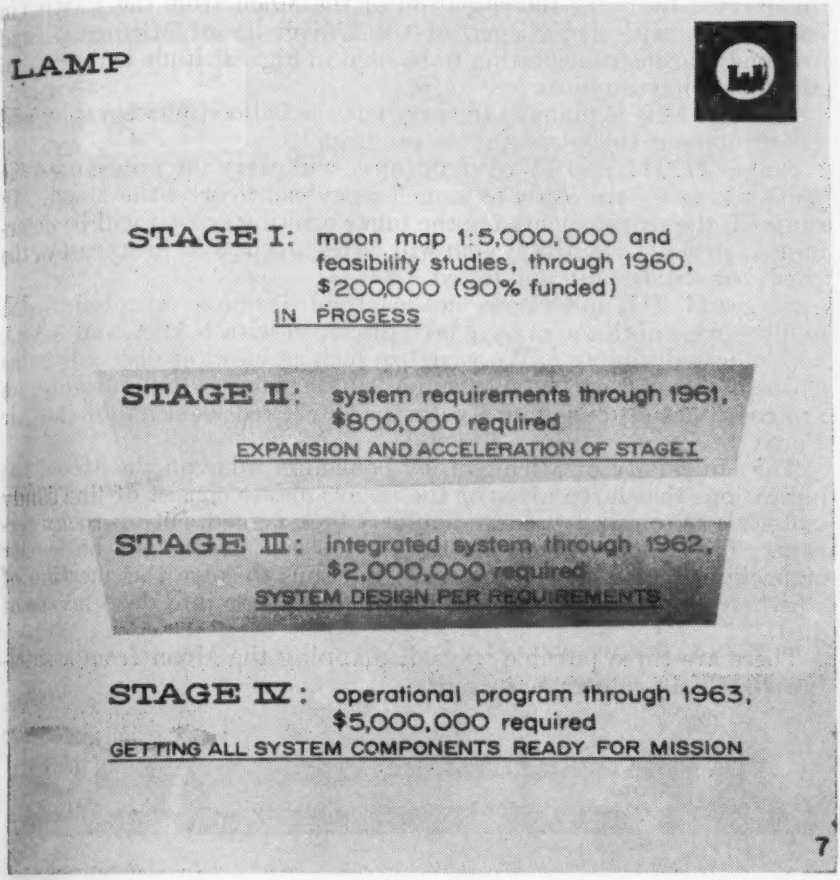
Our map of the Moon, which has come to your attention, is actually a relatively small part of our Project LAMP, which stands for "lunar analysis and mapping program."

FIGURE 2



Recognizing that lunar maps will be needed prior to unmanned as well as manned explorations, in 1958, the Army Map Service began studying methods of mapping the Moon. From these studies (fig. 2) grew Project LAMP, a comprehensive program that is currently underway (fig. 3).

FIGURE 3


LAMP
STAGE I: moon map 1:5,000,000 and feasibility studies, through 1960, $200,000 (90% funded)
IN PROGESS
STAGE II: system requirements through 1961, $800,000 required
EXPANSION AND ACCELERATION OF STAGE I
STAGE III: integrated system through 1962, $2,000,000 required
SYSTEM DESIGN PER REQUIREMENTS
STAGE IV: operational program through 1963, $5,000,000 required
GETTING ALL SYSTEM COMPONENTS READY FOR MISSION
7

In stage I of LAMP, Army Map Service, with the U.S. Geological Survey, is using currently available photographs, radar reflection data, and other material to prepare a 1:5,000,000 map of the visible side of the Moon. A map at that scale would represent the area of the United States in about 3 feet of width which will give you some idea of the scale involved.

The principal results of this effort will be the production of a horizontal control network on the Moon, through the use of a large digital computer. We have to call this lunar surveying process "selenodesy," because the word "geodesy" applies only to the Earth. With this selenodetic grid we can thus locate on a map, more accurately than has been possible before, the craters, maria, and other known features of the lunar surface.

The "maria" as you probably know are the so-called seas or flat areas on the Moon's surface.

We are also examining methods to improve our knowledge of the lunar crust by radar interrogation of the Moon from the Earth (in cooperation with Dr. Siegel, of the University of Michigan), and are studying instrumentation to be used in high altitude balloons and Moon orbiting satellites.

In stage II it is planned to carry out the balloon photography and radar interrogation phases of the program.

Stages II, III, and IV of the project will carry the program to the point where we are ready to launch a payload to orbit the Moon. In stage II, the requirements for the lunar orbiting system will be determined; in stage III, the system will be designed; and in stage IV, the hardware will be built and tested.

Stages II, III, and IV are not yet funded; our technical approach and progress in this area have been discussed with NASA, and NASA has indicated interest. We visualize such an effort as demanding the skills of many scientific and engineering agencies. For instance, we are coordinating our efforts with the interested elements of the Air Force.

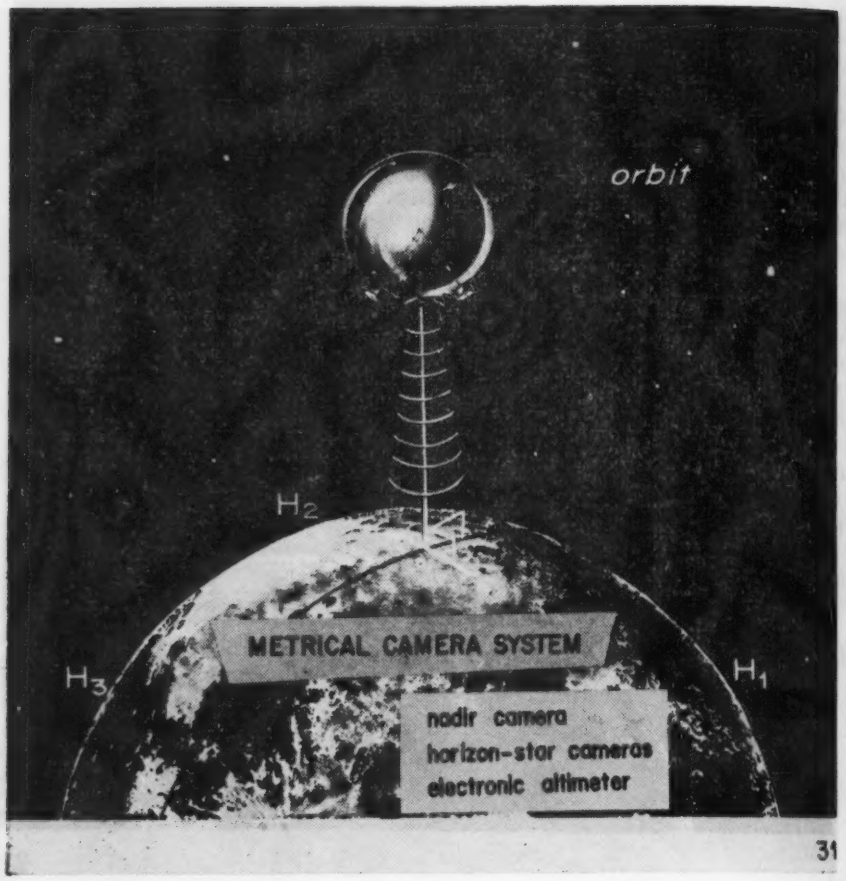
The University of Michigan, by bouncing radar off the Moon, has indications that large areas of the lunar surface consist of fine sandy material, as opposed to large boulders or a jagged, cut-up rocky terrain. They hope to determine the particle size, depth, and the density or packing factor of this material, and thus to solve the question of whether or not a landing vehicle will disappear into deep layers of dust.

There are three possible ways of mapping the Moon from a satellite: by TV, by camera, or by radar.

FIGURE 4

As shown on this slide (fig. 4), the television system would take pictures of the Moon and transmit them to Earth. To orient these pictures, another TV camera in the satellite takes and transmits a picture of the stars at the same time, as shown in this insert at the upper left.

FIGURE 5



The camera system (fig. 5) is similar to the TV system, but it requires that the payload containing exposed film be returned to the Earth and recovered.

FIGURE 6

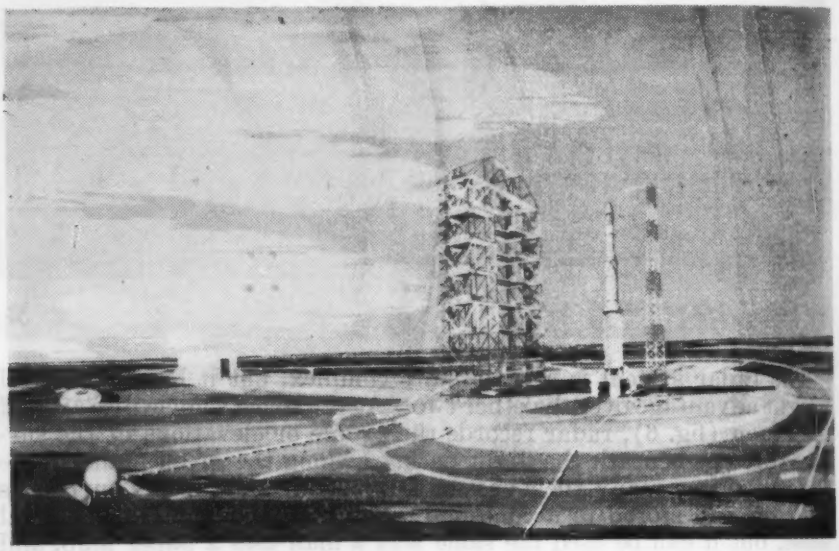
The radar system is a little more complex, but it has a potential weight advantage over the other two. As the space vehicle flies around the Moon (fig. 6), radar records the profile or elevations of the surface directly beneath the flight path. (Along the green plane in the slide.) After many such passes, a record of the Moon's surface is built up and stored in a computer. This is not a map in the usual sense, but it can be used the same way a man uses a paper map, and also by plotting many profiles a map could be produced if it was found desirable.

If you will now visualize this vehicle as a manned space ship intent on landing, I shall describe how a machine can use such a map. A computer in the vehicle contains the radar information already obtained by the earlier satellite. This space ship measures the profile beneath it as before; its computer electronically compares these data with that stored in its memory file, and automatically establishes the position and direction of the flight path.

Each of the three systems—television, camera, and radar—has advantages and disadvantages. We are investigating and evaluating all three. It is too early to predict which system is best, but by the time a lunar mapping mission is feasible, Project LAMP can provide the payload.

In the field of construction, there are areas where the Corps of Engineers also can materially contribute to the national space effort. As construction agent for the Army and the Air Force, we have built missile launching, tracking, and test facilities at Redstone Arsenal, Cape Canaveral, and elsewhere. Our total construction program, including civil works, has averaged over $2 billion a year for the past 10 years.

FIGURE 7



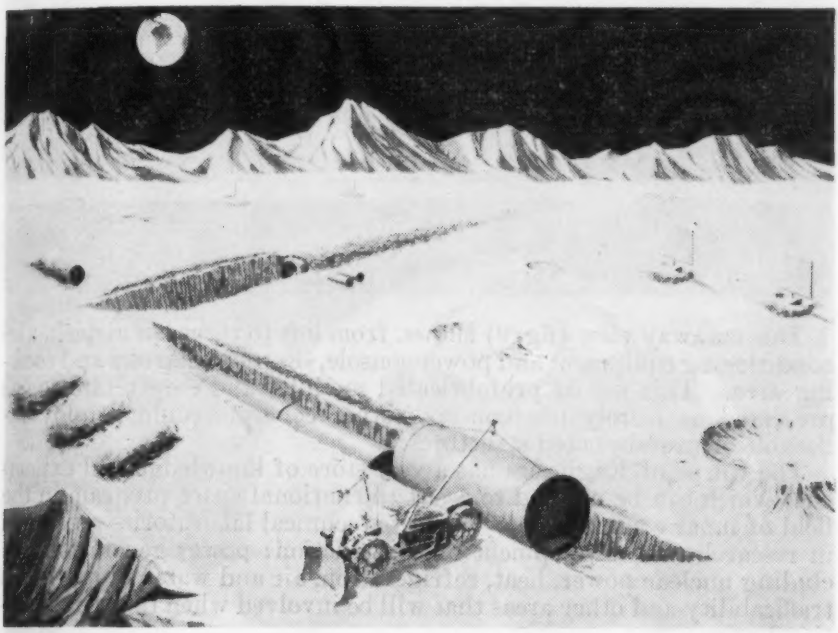
This shows a recent large missile-support project (fig. 7), the Saturn service tower, now under construction for Cape Canaveral. It is 305 feet high, taller than any structure in Florida, and it can be moved away from the launch pad on wheels before the countdown begins. There is also a model over there in the corner of the tower with a Saturn missile in place. Other facilities begun for Army Ballistic Missile Agency and to be completed for NASA include the Saturn launch complex at Cape Canaveral, and transfer facilities to allow transportation of the boosters to and from Huntsville by barge. They must move by barge because of limited clearances on railroads

and roads. We recently completed modification of the Saturn static test stand at Redstone Arsenal.

The Corps of Engineers can perform design, construction, and real estate services for NASA, wherever required. Our worldwide district organization, together with the Bureau of Yards and Docks of the Navy, is capable of meeting the needs for all military and nonmilitary construction in support of space.

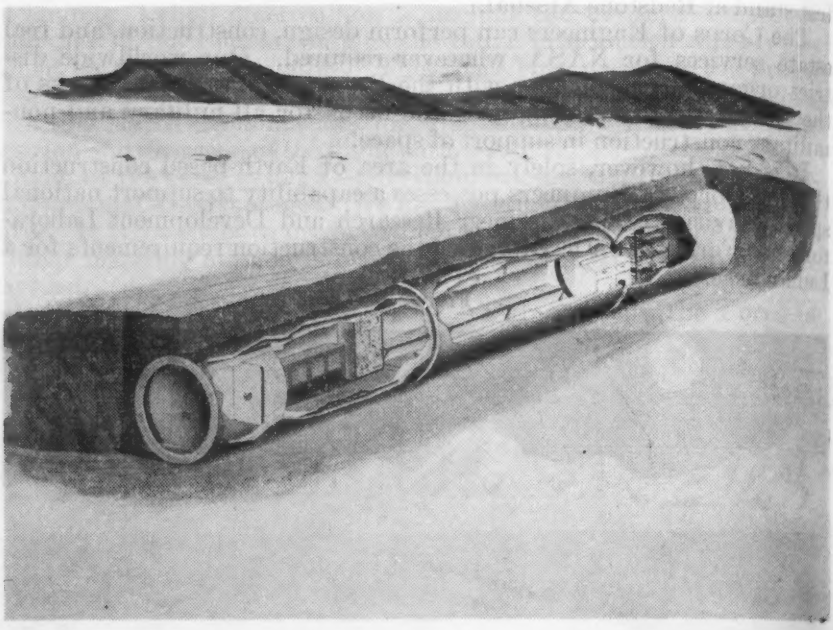
It is not, however, solely in the area of Earth-based construction that the Corps of Engineers possesses a capability to support national space activities. The Engineer Research and Development Laboratories at Fort Belvoir have studied the construction requirements for a Lunar base.

FIGURE 8



Here is an artist's view of one concept for an early Lunar base (fig. 8). The structure consists of prefabricated modules and is designed for assembly on the Moon with a minimum of labor. Each complete module is transported to the Moon by one cargo rocket. The base must be buried for heat insulation and for protection against radiation and meteorites. Small nuclear reactors, shown with their heat radiators, will provide electric power and heat for operating the base. A multipurpose vehicle performs all the heavy construction tasks. Empty tankage from the transport rockets is used for storage of supplies and for waste disposal.

FIGURE 9



This cutaway view (fig. 9) shows, from left to right, an airlock, air-conditioning equipment and power console, sleeping quarters and cooking area. This use of prefabricated modules and empty tankage is presented as merely one concept; other concepts could employ inflatable or prefabricated structures.

The Corps of Engineers has a vast store of knowledge and experience which can be utilized to assist the national space program in the field of lunar construction. We have technical laboratories renowned in research and development of construction; power generation, including nuclear power, heat, refrigeration, air and water supply, soils trafficability and other areas that will be involved when lunar exploration begins.

We have considerable background with construction and operation under severe conditions here on Earth. This summer, we will build a 100-man semipermanent camp, complete with nuclear powerplant, inside the Greenland icecap. This camp will be used by the Army Polar Research and Development Center, and will be called Camp Century. It is called Camp Century because it is approximately 100 miles out on the icecap.

It has taken years to develop this capability to work in the Arctic, the most hostile environment on Earth, but warm and friendly compared to that on the Moon.

For instance, in the Earth's polar regions the temperature varies annually from about +50° F. to −100° F.; on the Moon it varies from above that of boiling water (212° F.) down to −270° F, depending on whether the area is in sunlight or shadow. In addition, man must contend with a near absolute vacuum, solar and cosmic radia-

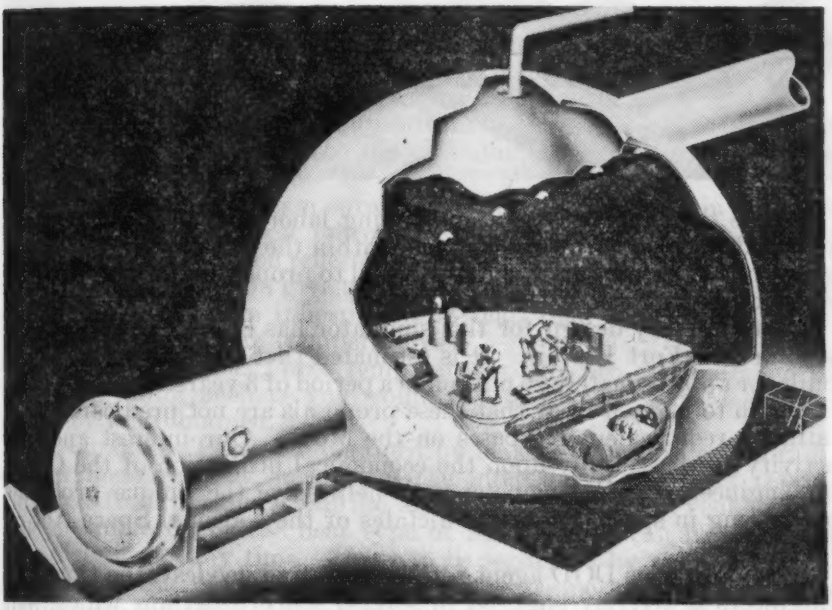
tion, and meteorite bombardment. The lunar gravity, one-sixth that on Earth, would be an advantage, however.

Our experience with construction in hostile environments leads to the conclusion that a long leadtime research and development program is required before we can safely and efficiently exist on the Moon. Such a program of research in space construction must proceed concurrently with the development of our space boosters.

Within the next decade our rocket vehicles will be able to transport exploration teams to the Moon. Your committee is familiar with the great effort and the millions of dollars being expended toward development of the Saturn, the Nova and more advanced rocket boosters. Their development will be one of the great achievements of modern engineering and scientific technology.

Similar emphasis is needed to develop the ability for man to exist on the Moon. Construction of a lunar base will have to precede all but preliminary exploration on the lunar surface. The development and testing of the material, equipment, and techniques required to build and operate this base must be accomplished on Earth prior to going to the Moon.

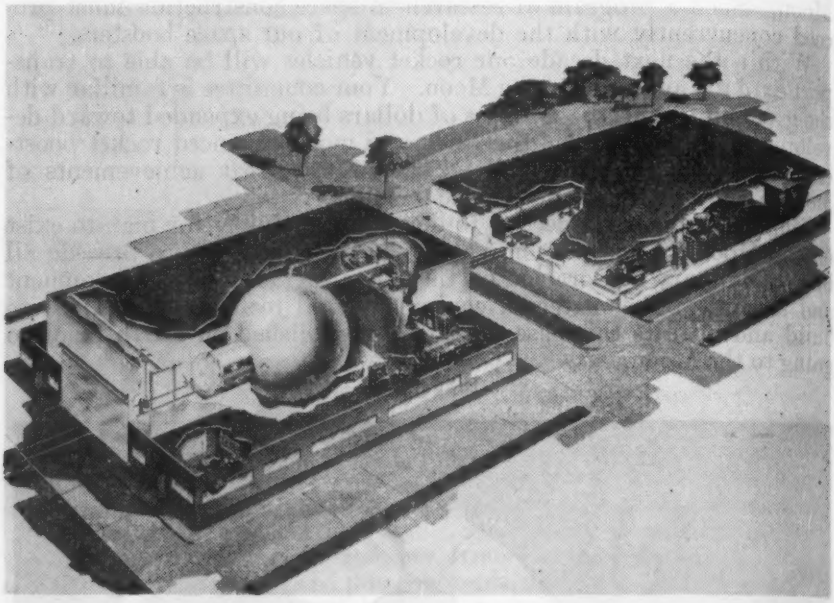
FIGURE 10



This slide (fig. 10), shows a research environmental similator, conceived at the Engineer Research and Development Laboratories, 10 meters in diameter, in which the temperatures, radiation, and vacuum existing on the surface of the Moon could be simulated. A simulator such as this is a prerequisite tool for acquiring the knowledge to survive on the Moon. In this concept a liquid nitrogen refrigeration system and special heat lamps will permit the temperatures inside the chamber to approximate those on the Moon and the near vacuum of

outer space will be reproduced adequately. Much research must be effected as to the utilization of special materials and construction techniques if man is to survive in the lunar environment.

FIGURE 11



Beside the chamber itself, supporting laboratory facilities will be required to conserve operating time within the simulator. This slide shows one of the appurtenances essential to proper operation—a liquid nitrogen refrigeration plant (fig. 11).

A preliminary design for this simulator has been prepared by our scientists at Fort Belvoir. It is estimated that the simulator can be built for approximately $6 million in a period of 3 years.

I wish to make it clear that these proposals are not predicated on a military requirement for bases on the Moon. Our interest and our activity are based only upon the economical utilization of the Corps of Engineers special competence to help solve the unique problems of existing in space within the dictates of the National Space Act of 1958.

In summary, as DOD agent for mapping and geodesy, the Corps of Engineers is actively engaged in several space programs which will contribute to the enhancement of our scientific knowledge of the Earth and the Moon. We are assisting NASA and DOD in meeting their requirements for Earth-based construction.

We believe a research and development effort to develop the capability for space construction should be undertaken soon if man is to have the capability of existing on the Moon. We stand ready, with the full resources of the U.S. Army Corps of Engineers, to serve the Nation in this age of space.

That, Mr. Chairman, completes my statement, sir.

The CHAIRMAN. Thank you, General Itschner, for a very fine statement. It is as clear a statement on this subject of mapping as we have had before this committee to date. We are very interested in the assistance that the Engineers give to this program. I think the public generally feels that the Engineers constitute an organization of people that have their feet on the ground, so to speak, that they are very practical men, and are not going to lead the Nation into a wild program that has no practical significance.

You are building these so-called towers? You are building that for——

General ITSCHNER. Yes, Mr. Chairman; we are building the Saturn towers. Of course we have built many towers at Cape Canaveral, at Vandenberg, and Huntsville.

The CHAIRMAN. Therefore it would be natural to call on you to build those. In mapping the Moon, is there any particular importance for mapping the Moon, other than the possibility that ultimately we can get a man up there and it would provide him some environmental knowledge before he arrives there?

General ITSCHNER. I think the prospects of getting a man on the Moon make it very desirable to know where that man could best land, which can be accomplished best by the preparation of maps in advance, so that that can be studied and so that the proper landing points can be determined. Aside from the general desirability of being the first Nation to have an accurate map of the Moon, I think that that is the principal purpose.

The CHAIRMAN. Is there any advantage in having a map of the Moon for the purpose of the use of radar in bouncing rays off the Moon?

General ITSCHNER. I am sure that a map of the Moon in order to determine where the best reflecting surfaces are would assist in the project to have the Moon reflect radar rays.

The CHAIRMAN. You give temperatures on the Moon. You say the climate is much more inhospitable to man than the Polar regions. How do you obtain those temperatures?

General ITSCHNER. Those temperatures, sir, are approximate, of course. I think perhaps you would like to ask Dr. Quarles exactly how they were obtained.

Dr. QUARLES. Those are obtained by making what are called radiometer measurements, measuring the intensity of the light that is radiated from the surface of the Moon, not so much the visible light, but the infrared or the heat type of light, which can be measured at a distance at any time. This can be separated by a suitable technique from the reflected light to give the temperature itself. It is comparable to telling the temperature of iron by the color, for example red hot, white hot, and so forth.

The CHAIRMAN. Is that reasonably accurate?

Dr. QUARLES. Yes. By "reasonably accurate," I think we have to think in terms of a spread, as with all measurements, but these temperatures should be correct to within a few degrees at the worst.

General ITSCHNER. I would like to point out to the chairman that this change in temperature, totaling something in the vicinity of 482°, occurs in 1 lunar-day. So the changes are extremely abrupt. There-

fore they create some serious problems if man is ever to live on the Moon.

Also, the maximum temperature, 212° F., while it is the temperature of boiling water at sea level on the Earth, in the near vacuum on the Moon that would be much above the boiling point of water.

The CHAIRMAN. With the difference there in pressure, the boiling point would be even lower——

General ITSCHNER. Much lower than the 212°. We have a situation where water would freeze extremely hard immediately at sundown, and when the Sun came up in the morning, it would boil very, very violently.

The CHAIRMAN. Why would the gravity, one-sixth of that of the Earth, be an advantage?

General ITSCHNER. It would be an advantage in lifting construction materials, lifting the dust or whatever is on the surface of the Moon, in order to make the excavation to get beneath the Moon's surface and provide living facilities. The only way we could withstand this great variation in temperature with any facility would be to get beneath the surface where the changes would not be so abrupt.

The CHAIRMAN. Just emerge from there during the hospitable time of the day?

General ITSCHNER. We would, of course, have to be protected in getting inside of them and in constructing them. Insulation would have to be provided in any space vehicle in order to get through space.

The CHAIRMAN. Mr. Sisk, do you have any questions?

Mr. SISK. General, I certainly want to concur in what the chairman said with reference to your statement. It is an excellent statement on what you are doing, and on the capabilities of the corps.

I would like to ask you first, Just what you suggest that this committee might be able to do to support your program? Do you have any specific suggestions on it, General?

General ITSCHNER. Mr. Sisk, thank you very much for your kind remarks. I believe that the committee could support our program by including for the record a statement in support of our existing and suggested programs.

Mr. SISK. Certainly as far as I am concerned, I think you do have support in what you are doing. I for one have been very much interested in this mapping program that you are carrying on, because, as I understand it, it is going to be imperative that we have a better understanding of the surface of the Moon before we can land anything there—that is, any manned vehicle. So far as your overall program, of course, I know from experience something about your capabilities in the construction field. I want to say, General, that I think that you do have the support of the Congress in carrying forward your program in both fields.

Is there any duplication or overlapping between your programs and those of other governmental agencies, since there are several agencies that may be involved in like programs?

General ITSCHNER. No, sir, we believe very strongly there is no undesirable overlapping of these programs with the programs of other governmental agencies.

In the field of lunar mapping, the Air Force work—and they are doing some work in that field—is complementary to ours. Theirs is more in the nature of obtaining aerial photographs, whereas ours is utilizing photographs to produce the final product, which is a map. We work very closely with the Air Force in this endeavor of theirs and ours and are insuring there is no duplication, so that each one is taking the maximum advantage of the capabilities of the other.

In the field of construction, both the Corps of Engineers of the Army and the Bureau of Yards and Docks of the Navy are involved, as we are in all types of construction. We coordinate our activities very well to insure there is no undesirable overlapping by these two services.

Mr. SISK. Very good, General. I, of course, have been interested in this construction program because NASA does have a considerable amount of construction ahead in various fields. I have been interested as to the experience and capability of the corps and the Bureau of Yards and Docks and others in this area. You have already commented to some extent on that. I wonder if you would add anything to what you have said with reference to the experience and capabilities of the corps to do the overall construction job, particularly in these launching pads, towers and things of that type, as it might be compared to some other agency of Government in doing this?

General ITSCHNER. Yes, sir. During fiscal years 1959 and 1960 approximately one-half of all the military construction funds received by the Corps of Engineers for Army and Air Force, which amounted to $800 million annually, have been devoted to missile and missile-support construction. Facilities designed and constructed have included facilities for all the major missile teams for the Army and Air Force and they include missile-assembly buildings, storage, distribution, and loading facilities for exotic fuels, liquids and high-pressure gasses, launching stands—such as the one in the corner there, which is a model of the Saturn stand—service towers, blockhouses, laboratories, guidance and tracking stations, and many other supporting facilities.

Static testing stands for large missiles have been built for a great many areas actually, and a two-chamber test stand for rockets of 1½-million-pounds thrust each with ultimate capability of 6-million-pounds thrust is under construction. Complete launching facilities are being constructed for ICBM's as well as assembly, maintenance, and tracking facilities for satellite systems. Ballistic missile early warning facilities are being constructed by the corps in two parts of the world.

This wide variety of facilities directly related to testing, launching, support, and tracking of missiles is a large part of the worldwide Army Engineers construction program that, as I indicated before, has averaged something over $2 billion per year since the outbreak of hostilities in Korea.

The CHAIRMAN. Will the gentleman yield?

Mr. SISK. Yes.

The CHAIRMAN. As I understand from your statement, General, roughly $400 million of your construction program is building facilities for rockets and the launching of rockets, matters in connection with the space program?

General ITSCHNER. Actually, sir, if you include both the Army and Air Force construction which we do, the amount has averaged $400 million. I said one-half——

The CHAIRMAN. One-half of $800——

General ITSCHNER. Yes, sir; it is one-half of $800 million, which is the total military construction program.

The CHAIRMAN. Your total space and missile construction program is $400 million a year now?

General ITSCHNER. Yes, sir. For fiscal years 1959 and 1960, sir.

Mr. SISK. General, how does the Army contract for design and construction? What is the procedure? In view of some questions that have arisen I was curious to know actually how these contracts are carried out, how the corps conducts their contractual procedures?

General ITSCHNER. Whenever possible, Mr. Sisk, contracts for construction are obtained by open competitive bidding resulting in fixed price contracts. During fiscal year 1959 94.1 percent by dollar value of all the Corps of Engineers' construction contracts, involving military construction for the Army and for the Air Force, were awarded by open competitive bidding.

We wish that it were 100 percent——

The CHAIRMAN. How much——

General ITSCHNER. 94.1. Because of the great urgency of a project or its remote location such as out in Kwajalein or something like that, we must at times negotiate. But even then we negotiate only after informal bidding by a number of selected bidders. The procurement of architect-engineer contracts on the other hand is done by negotiation because these contracts are of a professional-service nature.

The CHAIRMAN. I want to personally commend the Engineers for having that large percentage of open competitive bidding on their contracts. I agree with the general the higher he can move toward 100 percent in open competitive bidding, the better will the Congress and the public be satisfied.

General ITSCHNER. I can assure you, sir, that the only time we go to negotiation is when there is no other way out. Recently we were requested by the Air Force to construct a facility at Vandenberg Air Force Base for the Titan missile, which obviously was quite experimental. There would be many, many changes as it was being constructed and it had to be constructed with such a tight deadline that we most reluctantly agreed to execute a cost-plus-a-fixed-fee contract for that construction.

We certainly did not like to, and did it only because there was no other way out.

Mr. SISK. I certainly appreciate, and I agree with the chairman, I think that it is wonderful that your percentage of straight-bid contracts are as high as they are now. As I understand that 94 percent—I believe you said you did $2 billion last year. In other words, as I understand it, 94 percent of that was on a straight-bid contract?

General ITSCHNER. That $2 billion, sir, includes not only the military construction but civil-works projects, too. But even so the same statement applies.

The CHAIRMAN. That is total construction?

General ITSCHNER. Yes, sir. Actually, the percentage is perhaps increased a little because our civil works is entirely done by—I believe I can say entirely—done by advertised contract. I know of no exception.

Mr. QUIGLEY. Would the gentleman yield for one question?

Is that $2 billion, General, for construction contracts, the actual construction work, or does that include the designing and the engineering?

General ITSCHNER. The $2 billion figure, sir, which is an average figure, does include the design work and the supervision of these contracts, that still means that based on an average, 89 percent of that amount goes to the actual construction contracts, or a very small part of it to hired labor, but to the actual work. And the remainder is for design, supervision, and——

Mr. QUIGLEY. To get my thinking straight, out of an average $2 billion expenditure, roughly 90 percent of that would be for construction?

General ITSCHNER. That is correct.

Mr. QUIGLEY. Of that 90 percent, 94 percent is put out on contract?

General ITSCHNER. That——

Mr. QUIGLEY. Bid contract.

General ITSCHNER. At least 94 percent. It is 94 percent of the military construction. And I think it is 100 percent of the civil works.

Mr. QUIGLEY. Out of your money expended, the moneys that you would spend on other than a bid basis would be for designing?

General ITSCHNER. Yes, sir.

Mr. QUIGLEY. And in the instances of construction where because of Kwajalein or similar distances open competitive bidding would not be practical?

General ITSCHNER. That is correct.

Mr. SISK. I think you pretty well answered the question about percent of cost of construction. What percent is for Government costs, that is the so-called override? I think you gave a figure there already that probably indicated it pretty close.

General ITSCHNER. I could divide that a little further, because by Government costs we mean the cost for supervision, inspection, and overhead. And those costs are on an average 6.8 percent. The 11 percent total I gave you includes the design, which is the difference.

Mr. SISK. That is architectural designs and so on?

General ITSCHNER. Yes, sir.

Mr. SISK. What I had in mind was the actual governmental cost for this supervision and so forth. That figures out 6.8 percent.

General ITSCHNER. Yes, sir; during fiscal year 1959 for all of our military construction.

Mr. SISK. Do you have any idea how that compares generally with other agencies or other construction programs in cost? Is that high or low? I am not trying to get you to indict yourself now. It seems to be a fairly reasonable figure.

Sometimes it is said that if the Government handles construction and supervision it is higher. I was curious.

General ITSCHNER. I feel, sir, that figure is a very low one and it is as low as we can possibly obtain with the necessary Government

regulations which require certain things to be done which I think should be done, and which are involved in such a program. We do know that when States do work for us, as they do at times, for instance in a civil-works project in relocating a State highway—we often have the State undertake that work for us—that their costs for supervision, inspection, and overhead are certainly not less than the 6.8 percent I have given you here.

Mr. SISK. Mr. Chairman, and General Itschner, I certainly appreciate your comments on this. One further question: Do you have capability above and beyond your work for the Department of Defense outside of your civil-works program——

The CHAIRMAN. The civil-works program runs around a billion dollars itself.

General ITSCHNER. The current rate is just a little under a billion dollars. At the present time it is something in the order of $936 million in the budget request.

Mr. SISK. The point I was going to make: Are you pretty well loaded, or do you have capabilities to do additional construction for other agencies outside of DOD?

General ITSCHNER. Yes, sir; we do have a capability of doing additional work. Our organization is quite flexible and it is quickly adaptable to changing workloads. When work must be done in a new area, a new district area or project office may be established and staffed by an experienced personnel cadre from other districts.

Conversely when the workload decreases, districts or project staffs are inactivated. For instance, we just recently closed out the Garrison district in North Dakota because that dam was essentially completed. It is now just an operating area.

So we do have the capability. We have 41 districts in the United States spread throughout the country. We have eight districts overseas in such remote areas as Karachi, Pakistan, where we are doing a good deal of work for the Pakistani Army. Teheran, in Iran, the same situation—not building for our own Army or Air Force at all. And in other oversea areas, such as Korea, Okinawa, Honolulu, Italy.

Mr. SISK. Thank you, General. I think that is a very fine statement. I appreciate very much your answering the questions.

The CHAIRMAN. I think Mr. Sisk wanted to know if you had additional capital to take care of construction on the Moon.

Mr. SISK. We are looking forward to that, Mr. Chairman, you know.

The CHAIRMAN. You have a good, competent agency to take it over. General, some of the members were a little late. Two of them at least have asked me whether it wouldn't be possible to run a few of those slides over again. It is a bad policy because it encourages them to be late, but in this instance I think it is important and if it could be done, we would appreciate it.

General ITSCHNER. Figure 1 is a sketch of a new device called Secor which stands for "sequential correlation of range." It is an electronic distance-measuring system which will enable us to take intercontinental ties. Considering only the satellite pass shown in pink and the range measurements to the satellite shown in yellow, we can locate a point in Europe with respect to three stations at known locations in North America and South America.

Subsequent orbital passes are observed to increase the accuracy of our range measurements. Here on the table is a model of the transponder the Army will fly in the Transit satellite. Incidentally, our geodetic observations will provide the Navy with an independent check on the orbit they compute for Transit, and thus will contribute to the accuracy of their navigation system.

The CHAIRMAN. You are using this system to locate points in Africa and elsewhere?

General ITSCHNER. Yes, sir. We have found that many points on the earth's surface are not in the exact place that they were estimated to be. They may be out as much as several hundred feet. That is very important when we are talking about firing intercontinental ballistic missiles from the United States to these other points. Once we get established a few points in areas like that on the surveying structure, the system of locating points within that area all falls into line because we then know where the other points are in that mapping system.

Mr. MCDONOUGH. What satellite is now giving you these points?

General ITSCHNER. It is Transit satellite 2–B.

Lieutenant Colonel PEACOCK. The first satellite will be launched in early fall and it will be Transit satellite 2–B. We are building the equipment now for this transponder right now.

Mr. MCDONOUGH. Which one now is giving you the information?

Lieutenant Colonel PEACOCK. We are using the Vanguard satellite right now, sir, 1958 Beta, with our equipment. We have not flown this Secor equipment yet.

The CHAIRMAN. The Secor equipment will improve, will it, on the program?

Lieutenant Colonel PEACOCK. Yes, sir. With the Mark II minitrack equipment the accuracies that we are obtaining are in the neighborhood of 2,000 feet. With this equipment we will increase the accuracy down to 30 meters.

The CHAIRMAN. Could we take a nearer look at this equipment? Mr. Carstarphen, would you let the members see it?

Lieutenant Colonel PEACOCK. That is the flight equipment that goes in the satellite itself. That is the transponder. On the ground there will be portable Secor stations mounted in vans that we can move around in an airplane or under a helicopter or in a truck, two vans to a unit. There will be four stations as the slide shows.

Mr. MCDONOUGH. What elevation would you fly that?

Lieutenant Colonel PEACOCK. The transit elevation would be in the neighborhood of 500 nautical miles.

Mr. MCDONOUGH. Circular orbit——

Lieutenant Colonel PEACOCK. It will be as nearly circular as possible.

Mr. MCDONOUGH. This is for more accurately mapping the Earth?

Lieutenant Colonel PEACOCK. This is to get more accurate intercontinental geodetic ties. There are 14 data on the surface of the Earth. Our problems have been to tie these data together. We have done it in the past by using Hiran, but now using satellites we can get these ties very accurately over long distances. Our first try was

Project Betty with a Mark II minitrack, accuracies up to 2,000 feet. We are bringing this accuracy down to 30 meters by using this particular system, and to also locate remote Pacific islands.

Mr. McDONOUGH. This is being plotted and revised on the maps that we have. As you find a more accurate location of these areas you plot it?

Lieutenant Colonel PEACOCK. Yes, sir. This is the thing that gives point-to-point accuracy for location purposes. This is what we are increasing, this accuracy in the maps we have.

General ITSCHNER. It principally takes the form of changing the grids. It would not change the map itself.

Mr. McDONOUGH. Won't you, by plotting such points on the Earth, discover whether the distance between two known points on the Earth is exactly the distance that we now know, or the distance that you find it will be?

General ITSCHNER. That is precisely correct.

Mr. McDONOUGH. That would then revise the face of the map; I mean, the distance from the African coast to the United States or vice versa, would be revised.

General ITSCHNER. Yes, sir.

Mr. McDONOUGH. This information therefore would be of military value because our intercontinental missiles could be more accurately aimed, the targets could be more accurately determined. This is only for the Earth. This doesn't go outside the Earth's surface.

General ITSCHNER. This is only for the Earth.

Lieutenant Colonel PEACOCK. It is not only for military use but for scientific purposes, too. You need tracking stations accurately located. One of the big problems has been the accurate location of all tracking stations. It has a scientific use besides a military use.

Mr. McDONOUGH. This will help us. We have done pretty good up to now without it.

Lieutenant Colonel PEACOCK. Yes, sir.

The CHAIRMAN. It is also for a future commercial use; isn't it? Isn't there a commercial possibility in the future?

Mr. McDONOUGH. Distance between points, of course, would help commercially.

General ITSCHNER. There is a possibility I suppose in the future that rockets would be used for rapid transportation and so on.

Mr. McDONOUGH. Mail delivery, commercial transportation.

The CHAIRMAN. In line with the questions, Does this means of locating places on the Earth's surface, does it afford you an opportunity to show elevation, too?

General ITSCHNER. No, sir; it does not. It is strictly on the surface of the Earth.

The CHAIRMAN. We got you away from your slides.

General ITSCHNER. I will show you figure 3 then. Figure 3 is just a chart showing the various stages of our operation and stage II is planned to carry out the balloon photography and radar-interrogation phases of the program.

Stages II, III, and IV of the project will carry the program to the point where we are ready to launch a payload to orbit the Moon. In stage II, the requirements for the lunar-orbiting system will be deter-

mined; in stage III, the system will be designed; and in stage IV, the hardware will be built and tested.

Stages II, III, and IV are not yet funded; our technical approach and progress in this area have been discussed with NASA, and NASA has indicated interest.

There are three possible ways of mapping the Moon from a satellite: by TV, by camera, or by radar.

As shown in figure 4 the television system would take pictures of the Moon and transmit them to Earth. To orient these pictures, another TV camera in the satellite takes and transmits a picture of the stars at the same time, as shown in this insert at the upper left.

Knowing the precise location of that particular star that has to be identified, you have to know which star it is, they can then work out the exact orientation of the camera and the position on the Moon's surface.

The CHAIRMAN. So it would be in a position to take a picture of the earth: is that it?

General ITSCHNER. It takes pictures of the Moon and transmits them to the Earth. In order to know how the camera is oriented, you have to have some fixed point. You can take a picture of a star, or you could take a picture of the Earth, but a star would be better if you knew which star it was.

The CHAIRMAN. Where is it generally located, on the Earth or Moon?

General ITSCHNER. The location of the picture that you are taking on the Moon, you know exactly where it is, how the camera was oriented to take that picture, and thereby know where it is on the Moon.

The CHAIRMAN. The camera would be in the satellite?

General ITSCHNER. Yes; and you know the position of the satellite. What you need to know is: How is the camera in the satellite oriented?

Mr. MCDONOUGH. Hasn't that been determined to some extent by Tiros that we shot up and has a camera in it?

General ITSCHNER. Tiros has been taking pictures of the Earth's surface. This is a satellite which would take pictures of the Moon's surface. In order to do that we have to know two things: We have to know the location in space of the satellite, which will be determined from the Earth. Then we have to know secondly how is the satellite oriented, how is it tipped, and therefore how is the camera within it tipped. We do that by taking a picture of a known spot in space, which will probably be a known star, and knowing those two things we will know how to orient the picture we get from the satellite to prepare a map of the Moon.

Mr. MCDONOUGH. It is a triangle that you set up.

General ITSCHNER. Yes, sir; a number of triangles.

Mr. MCDONOUGH. The star is in a fixed orbit and you know that would be a fixed point?

General ITSCHNER. We know the exact point of that star. We know which star it is and its exact location in space, and we determine the location of the satellite from triangulation from the earth or other means.

The camera system (fig. 5) is similar to the television system, but it requires that the payload containing the exposed film be returned to the Earth and recovered.

The radar system (fig. 6) is a little more complex, but it has a potential weight advantage over the other two. As the space vehicle flies around the Moon, radar records the profile or elevations of the surface directly beneath the flight path.

The CHAIRMAN. You would get the configuration there?

General ITSCHNER. Yes, sir, wet get the profile as we go along with the radar. It makes a jagged line. One path would be of virtually no value, but after many passes a picture is built up and we visualize it would be stored in a computer rather than plotting. It is not then a map in the usual sense, but it can be used the same way that a man uses a paper map.

If you will now visualize this vehicle as a manned space ship intent on landing, I shall describe how a machine can use such a map. A computer in the vehicle contains the radar information already obtained by the earlier satellite. This space ship measures the profile beneath it as before; its computer electronically compares these data with that stored in its memory file, and automatically establishes the position and direction of the flight path.

I personally believe, too, it would be quite feasible to make a map out of these profiles, but it would be more difficult and a time-consuming process. If you had enough paths you could make a map of the Moon.

The CHAIRMAN. If you had a satellite to fly around the Moon, very close to the Moon, you might use that sort of profile map to protect the satellite from actually hitting the Moon.

General ITSCHNER. Yes, sir; it could be used to control the flight of the satellite electronically.

The next figure shows a recent large missile support project, the Saturn service tower now under construction for Cape Canaveral (fig. 7). It is 305 feet high, taller than any structure in Florida. It can be moved away from the launch pad on wheels before the countdown begins. I believe that is a little deceiving in that picture because it looks as though it is only a few stories high. Actually it is about 27 stories high.

Mr. MCDONOUGH. You mean the entire structure could be moved?

General ITSCHNER. Yes, sir; it is moved on wheels, mounted in trucks. In the model there you can see it.

The CHAIRMAN. It is the tallest structure in Florida?

General ITSCHNER. Yes, sir.

Mr. SISK. Is that constructed of lightweight aluminum?

General ITSCHNER. No, sir; it is steel constructed.

Mr. SISK. It is quite heavy?

General ITSCHNER. It is quite heavy—2,800 tons.

Mr. MCDONOUGH. What sort of power unit do you use to move it?

General ITSCHNER. I am sure it is powered by electric motors.

Mr. MCDONOUGH. A self-propelled unit?

General ITSCHNER. Yes, sir.

Mr. MCDONOUGH. The power unit is in the structure itself?

General ITSCHNER. The power unit is in the truck, the truck structure that is beneath the framework, yes, sir. There are two of them, one on each side, of course.

Mr. McDONOUGH. You mean the structure is moved into place in order to set the rocket and then it is moved away from the rocket for firing purposes?

General ITSCHNER. That is correct. You will notice in the structure—somebody step up there and move some of those little supports—there are a number of semicircular supports on one side that go out and embrace the missile and hold it. Then each of the platforms gives access to the missile. Those are retracted back into the tower when it is desired to move away from the missile so as to fire.

Mr. McDONOUGH. This is a new system for firing rockets?

General ITSCHNER. Yes, sir. It is somewhat related to the stands that are down there now for the smaller missiles. This is much bigger than any of the existing stands and it is somewhat different in design too.

Mr. McDONOUGH. Heretofore we built the structure around the rocket and fired the rocket from the structure?

General ITSCHNER. No, sir; all the bigger missiles, the ones that I am sure you are talking about, have been fired with the structure pulled away, in order to save the structure from the effects of the blast from the rocket.

The CHAIRMAN. The heat would warp it.

General ITSCHNER. Yes, sir. We have lost some of the structures because of the premature explosion of the missile.

Mr. McDONOUGH. Wouldn't it be more economical to build a subterranean structure partially below the surface as a permanent structure? Would that be disintegrated by firing?

General ITSCHNER. No, sir; it would not necessarily be disintegrated. We are building, as you probably know, some facilities, these are for the Air Force, underground. But when you do construct a hole in the ground you have to still provide the framework around it for all the equipment and access points. The equipment inside one of these silos, as they are called, is very extensive and greatly complicated. I think that on the whole it is a little cheaper to build an above-ground structure rather than build the hole. The holes are quite expensive to construct.

The CHAIRMAN. You still have to have the structure for the purpose of working on the outside of the missile?

General ITSCHNER. Yes, sir; whether it is above ground or not. The reason for constructing silos underground is for the protection that is afforded.

Mr. McDONOUGH. Is it anticipated that these structures as we advance in the art of rocketry and the rockets will become smaller in size, in height?

General ITSCHNER. Yes, sir.

Mr. McDONOUGH. And still be as powerful?

General ITSCHNER. Speaking of military missiles, yes, sir, because we hope we can use solid propellants. Using solid propellants means you can build them smaller and be equally as effective. It has not been completely developed yet, but the Minuteman missile will be a smaller one.

For space exploration I am afraid the missiles will have to become larger because they will require much greater thrust than anything that has been developed heretofore.

The CHAIRMAN. Isn't the Minuteman Air Force?

General ITSCHNER. Yes; it is an Air Force missile. But we in the Corps of Engineers are engaged in construction for the purpose of launching them.

Mr. MCDONOUGH. How close do you go to the research and development stage? Most of your work is the practical construction work?

General ITSCHNER. Yes, sir. Our work is the construction necessary to test and launch these missiles and house them and so on.

Mr. MCDONOUGH. You conform to the specifications of the scientific-research development of the project that is under study?

General ITSCHNER. That is correct. We must know what the scientists have developed in the way of a missile. As you know, it is changing all the time. We are getting a great many changes while we actually have the construction underway. That is inevitable in a program that moves as fast as the missile field.

Mr. QUIGLEY. Who designs something like this?

General ITSCHNER. This particular structure was designed by an architect-engineer for us, based on the criteria that were given to us as to the missile itself.

Mr. QUIGLEY. Do you do any inhouse designing?

General ITSCHNER. Yes, sir.

Mr. QUIGLEY. What percentage would it be?

General ITSCHNER. On military construction we do probably only about 10 percent inhouse, although it is increasing as our workload is decreasing, as it is at the present time. In the civil-works activity it is about the other way around—we have about 90 percent of our civil-works design done inhouse and something less than 10 percent by architects.

Mr. QUIGLEY. The dams and things which the Corps of Engineers has an extensive background, you do a great deal of inhouse?

General ITSCHNER. Yes, sir. I would like to point out the same engineers on our staff can and do do both. The only reason why we have not done more of our design for military construction inhouse is because we have not been able to augment our staff sufficiently to handle the increased workload.

We have always felt that the military-construction program was at a higher level than it would be on a permanent basis. That is being borne out now because the military-construction program is decreasing.

Mr. QUIGLEY. You handle most of your civilian construction and design work on a district level. Do you handle work of this kind on a district basis or is this handled from some central headquarters? Is the district in Florida charged with this responsibility, or is there someone here in Washington?

General ITSCHNER. The district in Florida, which happens to be the Jacksonville district, is responsible for construction at Cape Canaveral. They have supervising them an office, a division office, in Atlanta, Ga. The Atlanta office in turn looks to our office in Washington to assist them in any major problems.

Mr. QUIGLEY. Do I gather from your earlier remarks that it is the Army Engineers' responsibility to design the silos and other paraphernalia for the Titan and ultimately the Minuteman?

General ITSCHNER. Ultimately for the Air Force in the current program. The Air Force in its Ballistic Missiles Division located in Los Angeles is doing the design, because the work is largely experimental. They turn over that design to us after our people have had an opportunity to work with them very closely in Los Angeles to make sure what they conceive for design is a practical construction design.

Mr. QUIGLEY. The actual construction responsibility is with the Army Corps of Engineers on the Titan?

General ITSCHNER. Yes, sir.

Mr. QUIGLEY. But the design is the Air Forces' responsibility?

General ITSCHNER. So far it has been the Air Force's responsibility. But we believe, and they have conceded, that once the major problems have been taken care of and changes become very little in concept, that they will turn over the design to us.

Mr. QUIGLEY. In connection with the Titan silos and the like, is that done inhouse by the Air Force or is that contracted out?

General ITSCHNER. That is contracted out by the Air Force.

Mr. QUIGLEY. It seems to me you have almost a Solomon-like decision to make. Where do you find architectural firms—you have not found one that has built a silo for a Titan before. How do you decide who can do the job?

General ITSCHNER. I am sure that there are a good number—many, perhaps—architect-engineer firms that would be capable of designing a silo of a new type. I say that because there is nothing really radically new about the design for a silo, even though it may never have been built, because we have other experiences which would let us know how to design a silo. The hole itself is nothing complicated. It is mainly a matter of designing the walls, the floor, the stands inside, and then particularly the very, very complicated equipment that must go in it.

Mr. QUIGLEY. Did the Army Engineers build the gantries for say the Atlas at Canaveral or is that an Air Force project?

General ITSCHNER. We built the stands for the Atlas at Canaveral.

Mr. QUIGLEY. These were designed by private engineering firms?

General ITSCHNER. Designed by the Corps of Engineers down there.

Mr. QUIGLEY. These were an inhouse design?

General ITSCHNER. No, sir. I can't say that. They were designed, in most cases by architect-engineer firms for us. Some of the work was done by us.

Mr. QUIGLEY. How about the Polaris-launching site at Canaveral? Was that an Army Engineer project or did the Navy handle that?

General ITSCHNER. We constructed that and I believe designed it. I am not sure about that.

Mr. QUIGLEY. The Army Engineers assumes the great responsibility for all these launching projects; whether the ultimate missile launched is Army, Navy, or Air Force; the chances are that you are the people who actually will build the gantry or the silo?

General ITSCHNER. We built everything, all the construction, that is, we have done at Cape Canaveral, sir, and Vandenberg, whether it is for the Army, Navy, or Air Force. The reason for that is a very simple one, and that is it is much easier for one organization to handle the construction at any one place. By the same token, the Navy

handles Air Force construction in some parts of the world. They even do construction for the Army in locations where they are already located.

Mr. QUIGLEY. I agree completely with your logic. It just doesn't always prevail in many areas of interservice activity.

General ITSCHNER. I can assure you there is no rivalry between us and the Navy as to who builds where. We work closely together.

Mr. QUIGLEY. Do I gather that the Air Force to date has not come up with the equivalent of the Army Engineers or the Navy SeaBees?

General ITSCHNER. That is correct. They do not have a construction agency. They have an agency that acts as liaison between the Air Force and the Army or Navy as the case may be. They have officers in our offices throughout the country—all the division offices—who in a sense supervise the work from the Air Force standpoint.

Mr. QUIGLEY. That is all, Mr. Chairman.

The CHAIRMAN. May I ask you two or three questions about the amount of money you have available for this mapping program? How much money are you spending on that, General?

General ITSCHNER. We have at the present time, sir, $180,000 total available.

The CHAIRMAN. What is your budget on that, then, for the coming year?

General ITSCHNER. As I showed you on that chart there, for stage I we have a requirement for $200,000. As the chart showed, 90 percent of it is funded, which is the $180,000. That work is in progress.

We have been encouraged to believe that we might obtain from NASA enough money to complete that stage I.

The CHAIRMAN. That is not a large requirement, but is that sufficient for your needs to accomplish what you want to do——

General ITSCHNER. That is enough for stage I, sir. For stage II, now, it is going to require a much larger amount of money. That is $800,000.

The CHAIRMAN. When are you going to get into that stage II?

General ITSCHNER. If and when we get the funds, sir.

The CHAIRMAN. Have you made a budgetary request for stage II?

General ITSCHNER. Yes, sir; to NASA.

The CHAIRMAN. Stage II would be completing that system requirement?

General ITSCHNER. We have indicated to NASA our requirement for that $800,000. We have not budgeted for it ourselves.

The CHAIRMAN. Does that come through NASA, that $800,000?

General ITSCHNER. That would have to come through NASA. We have funded the first part of this work at $180,000 from our own mapping funds. But we do not have anything in our mapping funds to continue that work when it becomes larger, as it will in fiscal year 1961.

The CHAIRMAN. If you have $800,000, that is your budgetary requirement for stage II, would that come through NASA?

General ITSCHNER. It should. Because we have no means of financing it ourselves.

The CHAIRMAN. Unless you make a request to the Congress.

General ITSCHNER. Yes, sir.

The CHAIRMAN. You would really be doing that for NASA in the overall program?

General ITSCHNER. Yes, sir. We visualize all this work should be done for NASA because that is within their charter; that is their function.

The CHAIRMAN. Will that complete stage II?

General ITSCHNER. That $800,000 will complete stage II. That divides as follows—$200,000 of that amount would go to the University of Michigan for research and $250,000 for the Autometric Corp.

The CHAIRMAN. What is that for?

General ITSCHNER. That is for some of the gadgetry that goes in it—the equipment, the electronic equipment that is required to do this work. Then the Army Map Service and the U.S. Geological Survey—I might say we work closely with them—would require $350,000.

The CHAIRMAN. Is the Army Map Service a part of the Engineers?

General ITSCHNER. Yes, sir. The Army Map Service is an organization located largely in Washington, which has the responsibility for the Department of Defense of preparing maps of the world.

The CHAIRMAN. Stage III, now what about that? When will you get to that and how much will you need on that?

General ITSCHNER. If the funds were obtained for stage II in 1961, then stage III would follow in fiscal year 1962, and it would require $2 million.

The CHAIRMAN. It is more expensive as you go along.

General ITSCHNER. Yes, sir. Stage IV is $5 million. That would complete the program. That, of course, would have to come in future years.

The CHAIRMAN. The date when you will need stage IV will depend on what happened in the meantime?

General ITSCHNER. Yes, sir.

The CHAIRMAN. The whole program, though, will cost you less than $10 million?

General ITSCHNER. Yes, sir. We estimate it would cost in addition to what we now have, $7,800,000 or plus the $200,000 for fiscal year 1960, a total of $8 million.

Mr. CHENOWETH. Do you want to finish the slides?

The CHAIRMAN. Mr. Chenoweth wants to see the slides. There is one more; isn't there?

General ITSCHNER. Now we come to the figure showing the construction. Here is an artist's view of one concept for an early lunar base (fig. 8). The structure consists of prefabricated modules and is designed for assembly on the Moon by one cargo rocket. The base must be buried for heat insulation and for protection against radiation and meteorites. Small nuclear reactors, shown with their heat radiators, will provide electric power and heat for operating the base. A multipurpose vehicle performs all the heavy construction tasks. Empty tankage from the transport rockets is used for storage of supplies and for waste disposal.

This cutaway view shows, from left to right, an airlock, air-conditioning equipment and power console, sleeping quarters, and cooking area. This use of prefabricated modules and empty tankage is pre-

sented as merely one concept; other concepts could employ inflatable or prefabricated structures (fig. 9).

This figure shows a research environmental simulator, conceived at the Engineer Research and Development Laboratories, 10 meters in diameter, in which the temperatures, radiation, and vacuum existing on the surface of the Moon could be simulated. A simulator such as this is a prerequisite tool for acquiring the knowledge to survive on the Moon (fig. 10).

I think it would be foolhardy to try to send anybody to the Moon without having a laboratory such as this to try out living conditions on the Moon before going.

In this concept a liquid nitrogen refrigeration system and special heat lamps will permit the temperatures inside the chamber to approximate those on the Moon, and the near vacuum of outerspace will be reproduced adequately. The problem is to get this intense heat down to very great cold very quickly. That is why a very large insulation is required in refrigeration and a large power requirement for heating.

Much research must be effected as to the utilization of special materials and construction techniques if man is to survive in the lunar environment.

Besides the chamber itself, supporting laboratory facilities will be required to conserve operating time within the simulator. This figure shows one of the appurtenances essential to proper operation—a liquid nitrogen refrigeration plant (fig. 11).

That covers all the slides, I believe, sir, that I gave.

Mr. CHENOWETH. As a member of this committee, General Itschner, it gives me great personal pleasure and considerable pride to welcome you before the committee. One of the greatest compensations of being in public life is the friendships that we make. I remember our first contact was right after I came to Washington many years ago.

General ITSCHNER. I can remember our trip together during the early part of World War II when I was in charge of Air Force construction and we went out to Trinidad and paced off the length of a runway to see whether an airfield could be lengthened. I must say we decided it could not be. I am sorry that I had to turn you down.

Mr. CHENOWETH. It has given me great personal satisfaction to observe your long and distinguished and brilliant career as a member of the Corps of Engineers. I think your presentation here today is ample proof of the fact that there is no one in Washington that I know of that is any more conscientious, and competent in presenting what you have to present. It has been very impressive to me. I want to congratulate you on the progress that you have been making.

I have a few questions, General, in connection with your statement. We hear a great deal about the Moon—we are going to shoot for the Moon, we are going to put people on the Moon. I notice in your statement that you predict within the next decade our rocket vehicles will be able to transport exploration teams to the Moon. In 10 years you think we will be able to put exploration teams on the Moon?

General ITSCHNER. I believe so, sir. I am quite sure of one thing, if we don't, some other nation might. I think we must be prepared to do it.

Mr. CHENOWETH. There is a great deal of speculation as to what the advantages are to being on the Moon. From a military standpoint,

is there an advantage or would this be for space and scientific use, experimental purposes? What would be the advantage of being on the Moon?

General ITSCHNER. General Lemnitzer feels there is no known requirement from a military standpoint to be on the Moon. But certainly from the scientific standpoint it would be quite desirable to establish a small base on the Moon not only to explore the surface and find out what it is but as a steppingstone to planets which might be quite useful in other ways.

Mr. CHENOWETH. How far away is the Moon?

General ITSCHNER. 240,000 miles.

Mr. CHENOWETH. Do you feel encouraged, General, from your studies and work so far that we are making really substantial progress in our efforts to reach the Moon?

General ITSCHNER. Yes, sir.

Mr. CHENOWETH. You feel encouraged?

General ITSCHNER. Quite encouraged. With the larger thrust rockets that are being developed, I think there is no question but what somebody could be placed on the Moon within the next decade. Of course the main problem is to get them back after they are there. That is what requires the big——

Mr. CHENOWETH. Do we have any idea at all, General, what we may find out on the Moon?

General ITSCHNER. They feel it is quite likely there is a good deal of so-called lunar dust, the size of the particles we are not sure about at this time. There is some question as to whether or not perhaps a vehicle landing on the Moon might be completely absorbed in such a dust layer.

The reason for that dust is that the Moon has virtually no atmosphere. Therefore it couldn't have any winds. It certainly has no rain. So therefore any dust that might occur from bombardment by meteorites would simply accumulate. That is something that is very important to know, of course.

Mr. CHENOWETH. Do we have any idea about any inhabitation on the Moon?

General ITSCHNER. There is no life of any sort. There couldn't be.

Mr. CHENOWETH. We are confident of that?

General ITSCHNER. I feel quite certain about that.

Mr. CHENOWETH. The strategic advantage would be to put us in a position to gather more information on outer space?

General ITSCHNER. That is correct. It would be a wonderful place perhaps to locate a facility to explore the entire Earth's surface, reflection for television transmission, although that probably could be done better from a satellite—also for communications and many things.

Mr. CHENOWETH. How long do you predict before we will put into use—you mentioned the three approaches, the television, camera, and radar. Which one of those is the most effective and efficient, would you say?

General ITSCHNER. That is something that we don't know yet. I think each one has advantages. The camera, of course, would be the best if we could recover the film, and it can be recovered, but how readily is the question.

Mr. CHENOWETH. We are using all three now; aren't we?

General ITSCHNER. We plan to investigate all three, yes, sir.

Mr. CHENOWETH. In a preliminary way, have we made any experiments with it?

General ITSCHNER. Not very far. Not in a space vehicle.

Mr. CHENOWETH. Is the Moon an essential factor, then, in the use of these three?

General ITSCHNER. Yes, sir. The purpose of using one or more of these three would be to investigate and map the surface of the Moon. Once that is done, I am sure that the next step would be to use the same equipment to map what might very well be more important areas of space, particularly the planets.

Mr. CHENOWETH. I thought you were going to use the first two to map the Earth.

General ITSCHNER. We are using some to map the Earth. But we are using those in a little different fashion. We are not trying to fill in-between points, but we are trying to establish on the Earth's surface better than we now have, definite points here and there. Often points that are parts of well-prepared and accurate maps within themselves.

Mr. CHENOWETH. Could you give us any idea, General, as to about when we might begin to get that first photograph of the Moon?

General ITSCHNER. I would say——

Lieutenant Colonel PEACOCK. In 1965 when the boosters become available——

General ITSCHNER. About the time frame of 1964 and 1965.

Mr. CHENOWETH. You expect to have your equipment ready to function then?

General ITSCHNER. I think we could have the equipment ready earlier, but to have the boosters——

The CHAIRMAN. It all goes back to the booster.

Mr. CHENOWETH. In the development of Saturn, wouldn't that be the development to put this equipment on the Moon?

General ITSCHNER. Yes, sir.

Mr. CHENOWETH. General, I thank you very much for this opportunity to ask you these few questions. We certainly appreciate the contribution that you are making. I see that you are putting the same efficiency into your work in exploring outer space and the Moon that you have put in as the director of civilian and military construction of the Army and other Armed Forces. It is a great pleasure to see you again.

General ITSCHNER. You are most kind to me.

The CHAIRMAN. You refer to this base that you are putting in in North Greenland. Is there any comparison or do you get any experience from the building of that base beneath the ice in North Greenland with the problems here on the Moon?

General ITSCHNER. Yes, Mr. Chairman. There is a great deal of similarity. You see this base that we are building in Greenland has to be excavated in the surface of the icecap. That is done in order to protect it from the elements outside. It has a complete living facility. It affords us the opportunity of finding out how the needs to live can be served in an installation of that type.

There are, of course, many differences, too. Conditions on the Moon would be much more extreme. But this is the nearest thing on Earth that we can construct to simulate conditions on the Moon.

The CHAIRMAN. It is a step forward in that direction?

General ITSCHNER. Yes, sir. It is not being done for that purpose, really. It has a much more immediate purpose in that we want to know how to establish facilities on the icecap. But it has the incidental purpose of being a prototype of what might be a system of living on the Moon.

Of course it does not have the pressurization that we must have on the Moon. It doesn't have the extreme environmental conditions that we have on the Moon, as the range of temperature is much less than we encounter on the Moon's surface. It is a step toward the development on the Moon.

The CHAIRMAN. Is that a military or civilian installation?

General ITSCHNER. Military.

The CHAIRMAN. Is it a classified installation?

General ITSCHNER. No, sir. It is an experimental station which might later have some military significance. But at the present time it is completely experimental.

The CHAIRMAN. The similarity between the two is that you have an unnatural living condition up there, and you have to simulate them beforehand, and then actually work them out. Then when you put people up there to live under those conditions, they are living under artificial conditions.

General ITSCHNER. That is correct. We are going to have on the icecap all next winter about 100 men living in this camp built beneath the ice.

The CHAIRMAN. They will be living under very extreme conditions.

General ITSCHNER. Yes, sir; extreme conditions.

The CHAIRMAN. Mr. Quigley.

Mr. QUIGLEY. I have only one question. General, can you or one of the members of your staff tell me what I did or did not do and what this committee did or did not do in regard to your stage II funding? In other words, in all of this fine print which I have just glanced at I can't tell whether it is in or out of the NASA budget? You are at stage I. Stage II has $800,000 for next year. Buried in this thing somewhere is that amount, or a reasonable percentage of it, to be found?

Lieutenant Colonel PEACOCK. Sir, to answer that question directly, those funds have not specifically been identified in the NASA budget to meet this requirement. We actually presented this requirement to NASA on the 9th of February 1960. At that time they had not budgeted for it. They felt if money could be made available, it would be to meet this requirement. They were very favorably impressed with the project. They said they would do their best to help us.

At the present time they have asked us to get together with the Air Force and integrate the Air Force work into LAMP and come back to them at the working level with an integrated program at which time they will indicate what type of funding is available to meet this requirement.

They stated they could not meet the $800,000 requirement at this time.

Mr. QUIGLEY. So far as the charts are concerned here, as of the moment we are not keeping pace with the several charts you have showed us as far as time is concerned?

Lieutenant Colonel PEACOCK. That is correct. We are slipping right now until the money can be made available, or some portion of it can be made available.

The CHAIRMAN. The general expressed the interests in the attitude of the committee on this project. I want to say, as far as I am concerned, the project impresses me very much. I think it is in very competent hands. I would like for NASA to know that we feel it is a worthy project of consideration by NASA. If anybody on the committee wishes to voice themselves along that line——

Mr. SISK. Mr. Chairman, I think I have voiced my position pretty definitely a while ago. I would like to reiterate at this stage that I certainly hope that NASA will go ahead and at the earliest possible time make this money available so this project can proceed.

I think you have made an outstanding case for it. As a member of this committee, I would urge full cooperation on NASA's part in this program, stage II, and I would hope of course in the other stages as the need arises.

The CHAIRMAN. Any further questions?

Mr. MCDONOUGH. I agree with the observations of the chairman and Mr. Sisk, that this is a very useful and necessary project that we should pursue and urge that NASA cooperate in it.

The CHAIRMAN. The Senate has shown interest in raising the amount. It is such a small amount, relatively speaking, that it ought to be worked out all right.

Before we break up, General, it is a pleasure to have had you here. I want to say also that the Engineers have had some very able Chiefs of Army Engineers in the past, but I know of none greater than our present Chief of Army Engineers. I was with you—I am not going to let Mr. Chenoweth get ahead of us here—I was with the general in World War II where the going was pretty rough. He was doing a very able job up there on the Albert Canal, opening up the canal so we could move in in support of our troops immediately in advance by the Albert Canal in the invasion of Germany.

The Engineers did a superb job in that respect. We are happy to have you here General. We wish you a lot of luck with this program.

If there is nothing further, the committee stands adjourned until tomorrow morning at 10 o'clock.

(Whereupon, at 11:50 a.m. the committee was adjourned, to reconvene at 10 a.m. Wednesday, May 11, 1960 on another subject.)

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